VII

SUPERGALAXIES

THE account of exploratory investigations has thus far passed over six of the eight territories mentioned in the introduction. Within the galactic system proper we traversed in turn the solar neighborhood, the region of lucid stars, the local system, and the Milky Way star clouds. The system of globular star clusters and the two Clouds of Magellan were next considered, and the possibility has been mentioned on an earlier page that these clusters and clouds may be but a part of the supersystem in which the star clouds of the Milky Way stratum are unit galaxies and form the major part of the organization.

If the diameter of the galactic system is actually much in excess of two hundred thousand light years, it may be appropriate to enquire if some of the nearer of the spiral nebulae—such as Messier 33 and the Andromeda Nebula—are not also a part of the supersystem dominated by our Milky Way. But whether or not our own Milky Way system is composed of several units, we are certain that such superorganizations do exist. The Andromeda Nebula has two fainter companions. The Magellanic Clouds may form, as we have said above, a double system. More than fifty binary galaxies are known among the fainter objects of the spiral nebula family, and there are several multiple systems.

The most striking of the supergalaxies is the one we have called Coma-Virgo Cloud A, which lies not far from the north galactic pole and spreads its stream of conspicuous

spiral and spheroidal systems over several hundred square degrees of the sky. On our present scale of distances the Coma-Virgo supergalaxy is approximately ten million light years away. In a study recently completed we have analyzed the distribution, brightness, diameters, types, and orientations not only of the three hundred or so galaxies in Cloud A, but also of the twenty five hundred similar systems that lie far beyond in the same direction. Many of these fainter, more remote galaxies are also grouped into clusters, and it is probable that some of the fainter aggregations lie more than a hundred million light years distant.

Further study of Coma-Virgo Cloud A during the past year has shown its extension across the constellation Virgo into the southern hemisphere. It now appears that this magnificent supersystem, of indefinite boundary, is a long stream of relatively bright external galaxies, but several million light years in extent and thus much larger than our own galactic system. Distinctly shown on the Harvard photographs are at least forty clusters of galaxies, many of which must be more than a million light years in diameter. This does not mean, however, that our own supersystem is uniquely small, either in population or in extent; for the supergalaxies range in diameter from some millions of light years to a few thousand. Stephan's Quintet in Pegasus, for example, appears to be composed of five ordinary spiral and spheroidal galaxies, four of which are essentially in contact and probably extend throughout less space than that occupied by the Milky Way star clouds in Scorpio, Sagittarius, and Ophiuchus.

The long-exposure photographs with the Bruce telescope provide sufficient material for systematic investigations of

the nearer of the supergalaxies. This telescope is not powerful enough to get to the bottom of some of the systems for which we have now photographed only the most luminous galaxies; probably no existing telescope can reach to the under-sized members of these organizations. Studies by Lundmark at Upsala, Hubble at Mount Wilson, Baade at Hamburg, and Miss Ames and the writer at Harvard have shown the considerable dispersion in the actual luminosities and the linear diameters of the members of the supergalactic systems. These diversities in brightness and diameter will make uncertain for years to come our estimates of the distances of the groups. Perhaps the relation between distance and the "red shift" of the spectral lines for external galaxies may eventually give us the most reliable indication of the distances. The whole study of external galaxies is necessarily on a less reliable basis than the studies of globular clusters and the Magellanic Clouds; but the systematic accumulation of observations of magnitudes, motions, diameters, and distribution must eventually provide material adequate for statistical considerations of the structure and distances of supergalaxies.

One of the richest and most distinct of the faint supergalaxies is in the constellation Centaurus. A preliminary survey of the magnitudes of the individual members has been published,[1] and a revision of the magnitudes has since been obtained. As the majority of the individual galaxies in this system are fainter than the seventeenth photographic magnitude, the problem of magnitude standards is serious. The difficulty has been met in a fairly satisfactory manner through establishing a magnitude sequence from counts of faint stars in the Centaurus field; the relation of the number of stars per square degree to a given limiting photographic magni-

[1] Harvard Bulletin 874, 1930.

tude has been determined statistically for all parts of the sky by Seares at Mount Wilson and van Rhijn at Groningen.

It is scarcely appropriate here to give details of the method of measuring the total brightness of the individual galaxies for the Centaurus group; I simply present a tabulation of the frequency of the revised magnitudes, showing how the galaxies grow more numerous as we approach the effective limits of the Harvard plates. Below magnitude

TABLE V

FREQUENCY OF MAGNITUDES IN THE CENTAURUS CLOUD OF GALAXIES

MAGNITUDE	NUMBER	MAGNITUDE	NUMBER
14.65	2	16.45	20
14.85	0	16.65	27
15.05	4	16.85	50
15.25	0	17.05	50
15.45	4	17.25	62
15.65	6	17.45	101
15.85	5	17.65	81
16.05	12	17.85	61
16.25	21	18.05	20

17.5 the survey is probably incomplete, and it fails entirely at the eighteenth magnitude. There is little doubt but that an extension of the survey to the twentieth magnitude would multiply many fold the number of recorded galaxies in the Centaurus supersystem. The distribution of the members appears to indicate that we see here a discoidal system more or less edgewise; in form it is not greatly different from the extended Coma-Virgo Cloud A, and perhaps it is not dissimilar to our own galactic system.